

Denver 800 MHz Interference

— Progress Report —

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For

The Federal Communications Commission

Outline

- **The Denver Problem**
 - Nature of interference
 - Techniques used to mitigate it
 - Relative success effort
- **AT&T's Contribution to the Problem**
 - Why it occurs
 - Extent of AT&T's contribution
- **Failure of the "Technical Toolbox"**
- **Why Denver Needs Re-Banding**

The Denver Problem

Denver Public Safety Radio

■ Frequencies

- Public Safety: 33 channels, 854-861, 866-869 MHz
- Utilities: 15 channels (25 kHz), 854-861 MHz

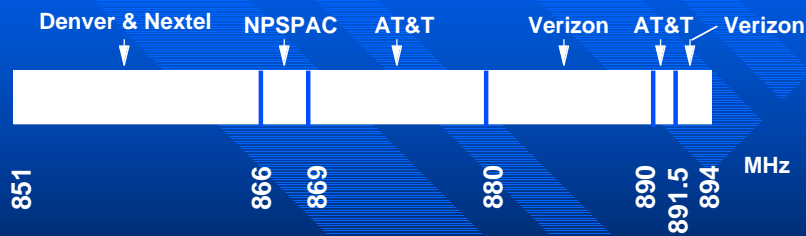
■ Equipment

- MA/COM EDACS Trunked Radio System/Analog FM
- Activated 1989

■ Site

- Main transmitter site on Mt. Morrison (7,750' AMSL)

Denver 800 MHz Band



Background

- Problem Discovered in Feb 2000 Following Officer Complaints
- Eventually 24 Sites Identified
 - Not static, still finding more
- Two Main Problems:
 - Receiver Intermodulation in Public Safety Receiver
 - Transmitter out-of-band emissions from Nextel transmitter
- Actions Taken & Proposed
 - Near-term: mitigation
 - Long-term: a phased channel swap and re-banding

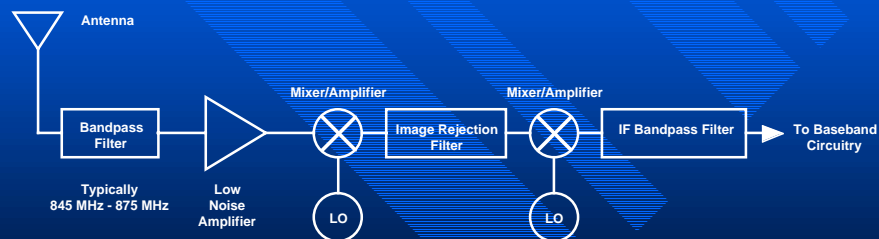
Problem Mitigation

Intermodulation (IM) Protection

- **Actions**
 - “Tune” Nextel site to preclude harmful IM products
 - Practically, can only protect control channels
- **Results**
 - Effective at roughly 18 of 24 problem sites
- **Limitations**
 - Only control channels are protected
 - Voice channels still experience interference
 - System often assigns user to a bad voice channel (one with IM)
 - Nextel limited in use of their spectrum

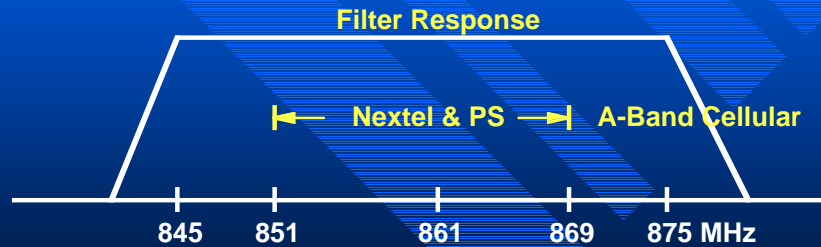
Public Safety Receiver

- **Weakness Is Bandpass Filter**
- **Today It Passes All of SMR, Much of A-Band Cellular**



Typical Bandpass Filter (Public Safety Receiver)

- No Protection From Nextel or A-Band Carrier

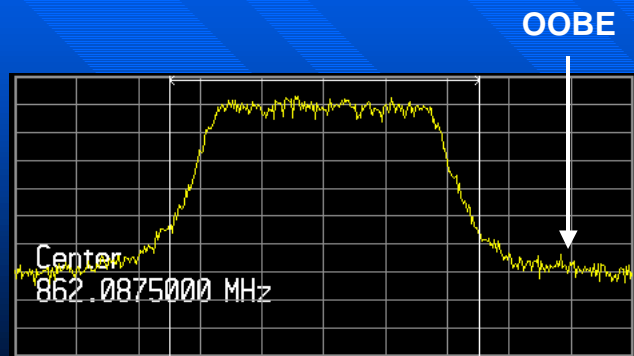


Problem Mitigation Transmitter Out-of-Band Emissions (OOBE)

- Actions
 - Nextel installed auto-tune cavity combiners
 - Greater filter selectivity reduces out-of-band emissions
- Results
 - Effective when channel separation is wide enough
- Limitations
 - Not effective for closely spaced frequencies (< 150 kHz)
 - 81 Interleaved Nextel Channels are < 150 kHz from Denver channel

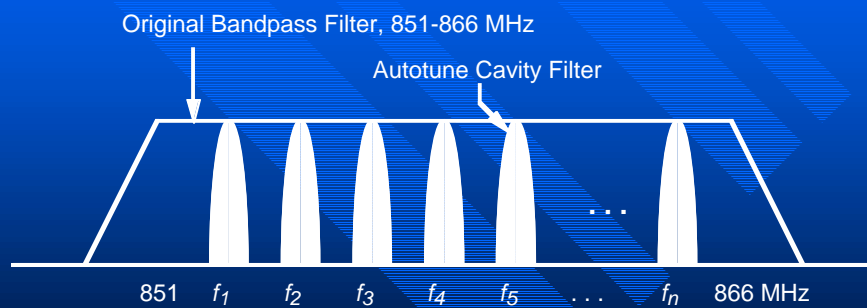
Nextel iDEN Signal

- OOBE Typically 63 dB Below Carrier



Filter Comparison

(Nextel Transmitter Combiner)

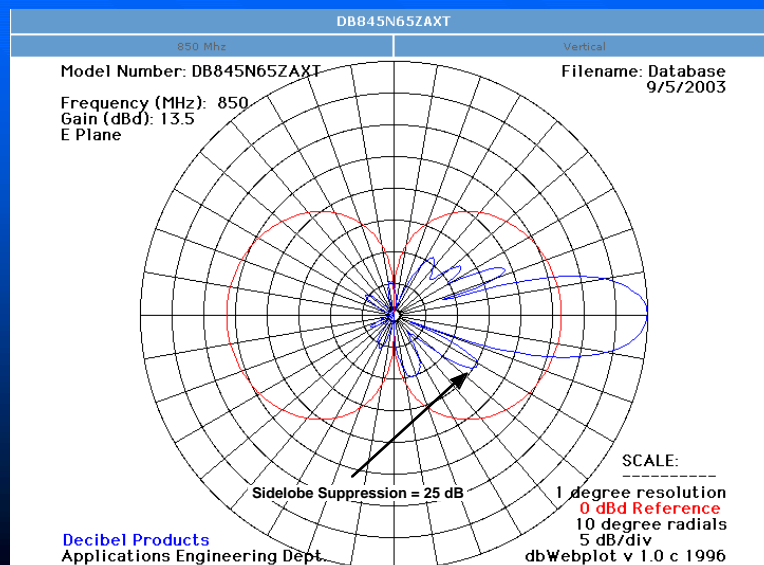


Problem Mitigation

Antenna Patterns

- **Actions**
 - Nextel installed antennas with reduced downward radiation
- **Results**
 - Reduces Nextel signal level on the street
 - Intermodulation products reduced by roughly 3 to 1 ratio in dB
- **Limitations**
 - Not effective for low sites
 - Can be close-in and still in main antenna lobe

Antenna Used in Denver



Antenna Issues

- Tried Sidelobe Suppression at Two Sites:
 - City Bank, 8-10 stories high, good results
 - 14th & Market, ~ 3 stories high, not effective
- Only works on relatively high sites (look down angle issue)

**But It's
Usually the
Low Site
(Alameda & Federal)**



**Another
Low Site
(48th & Elm)**



AT&T Wireless

Problem Statement

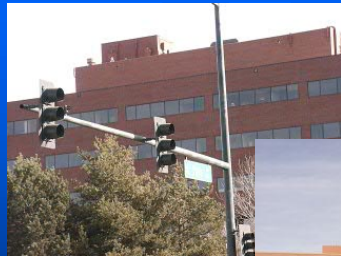
- After Mitigation, Six Sites Remained a Serious Problem*
 - Five of the six were co-located Nextel/AT&T Wireless
 - Mathematically, AT&T can contribute to receiver IM
 - IM can be AT&T alone (NPSPAC mostly) or with Nextel
- Conducted Measurements to Verify AT&T's Contribution

*These are the “red” sites. Denver also has lesser problems at several “yellow” sites.

Observations - AT&T

- Factors Contributing to Interference
 - AT&T is adjacent to NPSPAC band (869-880, 890-891.5 MHz)
 - Numerous theoretical IM “hits” on Denver NPSPAC channels
 - Numerous “hits” with Nextel frequencies in 855 MHz region
 - Denver receivers do not attenuate below 875 MHz
 - AT&T base stations pass transmitter noise below 869 MHz
- Mitigating Factors
 - Signal levels on street are lower than Nextel (in general)
 - Location in 800 MHz band limits AT&T 3rd order products
 - Most likely products are combinations with Nextel
 - Frequencies above 875 MHz attenuated (for some radios)
 - Transmitters not keyed continuously

Example: Yale & Colorado



Nextel Site
(East Side)

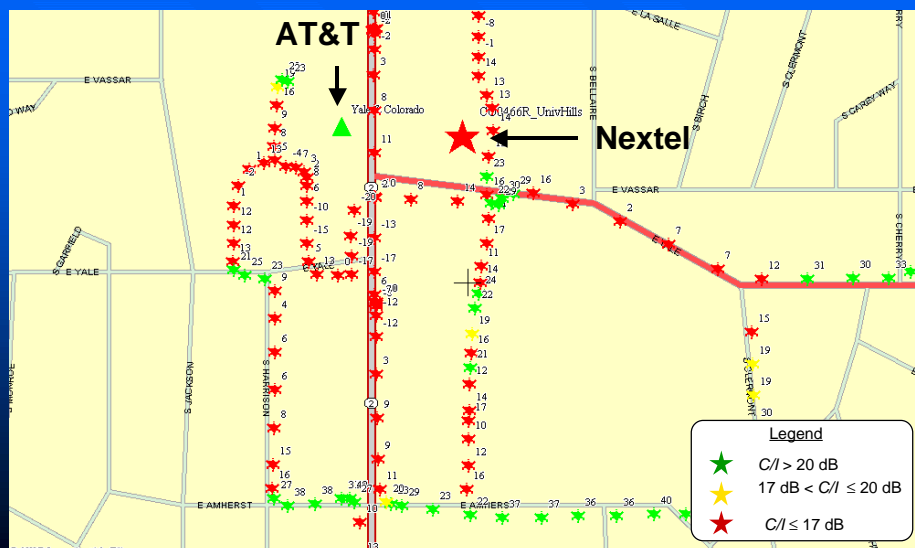


AT&T Site
(West Side, north
of Fire House)

Denver Fire House
(West Side)



Yale & Colorado



AT&T Results

- **AT&T Wireless Contributes to Receiver IM**
 - Predicted mathematically, confirmed by On-Off tests
- **Most IM Products Require Nextel Also**
 - I.e., IM that falls on five control channels
- **Note: Does not Include NPSPAC Interference**
 - NPSPAC (866-869 MHz) does occur with AT&T alone
- **AT&T Working With Denver & Nextel**
 - AT&T IM tuning to partially protect Denver control ch's
 - Testing to quantify any improvements
 - Traffic channels and NPSPAC still unprotected

Failure of Technical Toolbox

The “Technical Toolbox”

- Tools Already In Service in Denver:
 - IM Tuning at Nextel Sites
 - Auto-tune cavity combiners
 - Antennas with less downward radiation
- Other Tools:
 - Varactor Bandpass Filters
 - Switchable Attenuator
- Why Can't These Tools Do the Job Without Re-banding?

The “Technical Toolbox”

- IM Tuning
 - Limits Nextel's frequency choices too much
 - Only practical to protect a handful of frequencies (control ch's)
 - At congested sites, still have strong IM on traffic channels
 - Nextel alone can't control the Nextel/AT&T mixes
- Auto-Tune Cavity Combiners
 - Cavities have finite isolation
 - Not good for close-in channels (< 150 kHz)
 - Further limits Nextel's frequency choices
- Antenna Patterns
 - See REMEC FCC comments
 - They have right idea, but we are already doing this
 - Won't work at low sites where we have the problem

The “Technical Toolbox”

- Varactor-Tuned Bandpass Filters
 - Motorola suggestion, detune to create attenuator
 - Good idea, same effect as attenuator (below)
- Switchable Attenuator
 - Motorola innovation
 - Automatically switches in attenuator when desired signal strong
 - But the problem occurs when signals are weak already
 - Cannot afford a 15 dB hit in sensitivity at these levels
 - Introduces complex signal estimation problems
 - Still a research project, not a field-tested product

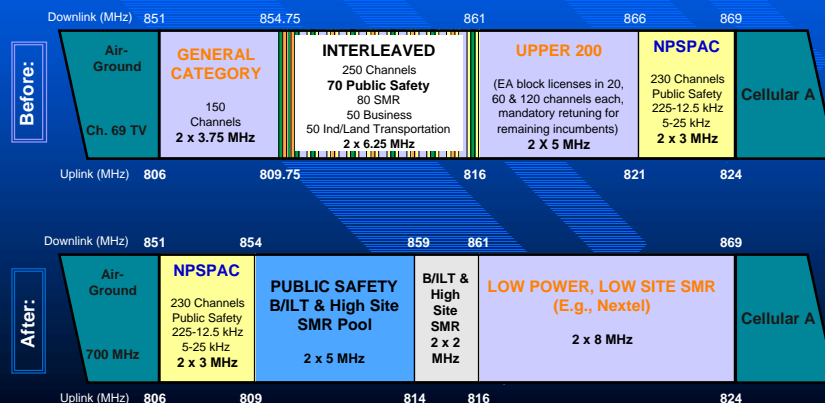
Why Denver Needs Re-Banding

Denver Needs Re-Banding

- Denver Has Tried the “Technical Toolbox” for 3 Years
 - Only partial improvements
 - These are stop-gap measures
- The Problem Will Only Get Worse
 - Nextel & AT&T will continue to build sites with low antenna heights
- Only Re-Banding Can Solve the OOBE Issue
- Receiver Technology Will Not Save Us
 - Amplifier & mixer technology is mature
 - No significant advances on the horizon
- Filtering at Receivers & Transmitters Only Effective w/Re-Banding

Consensus Plan

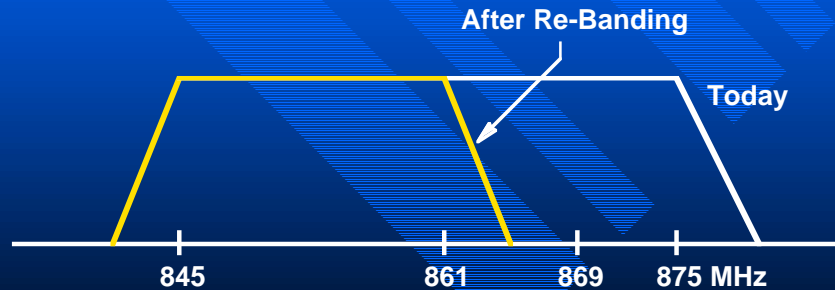
- Before: Interleaved Channels Plus 4 PS/Cellular Band Edges
- After: No Interleaving And One Band Edge



Filter Comparison

(Public Safety Receiver)

- Post Re-Banding Allows Effective Filtering at Receiver
- Eliminates IM From A-Band Carrier & Nextel/A-Band IM



Bottom Line

- Re-Banding creates band separation and contiguous spectrum that together make it possible to eliminate harmful out-of-band emissions and receiver intermodulation.
- Without Re-Banding, Public Safety is Faced with Unsolvable Problem

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